Turbulent Flow Measurement in Vortex Settling Basin

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Abstract

This paper presents the findings of an experimental study on the three-dimensional turbulent flow field in vortex settling basin. An ADV (Acoustic Doppler Velocity Meter) were used to catch 3D velocity components inside the basin. Detailed measurements of time-averaged velocity components, turbulent intensity components and turbulent kinetic energy were determined at different radial sections of chamber. The normalized time averaged absolute velocity of 3D components in contour type exhibition were conducted and it was found that the absolute velocity generally is influenced by u component of flow and from high magnitude in basin center trends to the constant magnitude in basin side wall.

The normalized turbulent intensity of three components were investigated individually first and it was found that intensity of 3D components in vicinity of central air core is higher than other regions, decreasing by moving towards basin sidewall except the sections that influenced directly by entrance flow jet and sidewall exiting overflow. The results of turbulence kinetic energy also had the same interpretation like turbulence intensity and affected by the same boundary conditions which cover turbulence intensity of 3 velocity components overly.

Keywords: Vortex flow, 3D Velocity distribution, Turbulence intensity, Turbulence kinetic energy.

1. INTRODUCTION

Sediment laden flows are capable to transport and deposit a considerable rate of sediment load in the conveyance channels which results in reduction of conveyance capacity of the system. Therefore, measures are to be taken to exclude the sediment particles from the diverted flow into the irrigation canals. Different types of sediment extractors/excluders, such as tunnel type, vortex tubes, rectangular settling basins and vortex type settling basins are often employed for this purpose. In recent years the vortex settling basin (VSB) has attracted a considerable interest among the water engineers. The vortex settling basin (VSB), is a continuous device which applies a certain fraction of flow for flushing the sediment particles out of the diverted stream [1]. VSB utilizes centrifugal forces to generate a vortex motion around its central axis to remove sediment particles from the incoming flow by means of secondary currents in the chamber through the central flushing orifice [3]. In this device the high velocity flow is introduced tangentially into cylindrical basin having an orifice at the center of its bottom. [4]. Resulting secondary flow causes the flow layers adjacent to the floor of the basin moving towards the central outlet orifice. Therefore, the sediment particles reaching the center of the chamber could be flushed out continuously through the orifice and a relatively sediment free water would leave the basin through its overflow weir crest [5].

The flow behavior in this device is so complex due to turbulent nature and secondary currents of flow field. It is believed that better understanding of sediment trapping in such structures is dependent to understanding of turbulence nature of flow in the basin. Limited researches have been carried out previously on flow structures of these type extractors. However, turbulence characteristics in the basin remain unexplored.

The vortex settling basins have been investigated principally by Vokes and Jenkines (1943), Velioglu (1972), Salakhov (1975), Cecen and Bayazit (1975), Sulivan et al. (1978), Curi et al. (1979), Mashuri (1981,1986), Svarovski (1981), Ogihara and Sakagouchi (1984), Sanmogantan (1985), Zhou et al. (1989, 1997), Paul et al. (1991), Ziaei (2000, 2001), Athar et al. (2002, 2003), Keshavarzi and Gheisi (2006) [2].

Most of these investigations in their experimental studies tried to focus on the trap efficiency of the vortex settling basin and express an appropriate relationship for its estimation.